EuroStrataform Analysis

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LONG-TERM GOALS

The long-term goal of this project is to develop quantitative models of sediment transport, resuspension, deposition and accumulation on the continental margin.

OBJECTIVES

The objectives of this research program are:

1) to examine the sediment transport mechanisms on the Po delta, particularly the role of fluid mud flows on sediment dispersal;

2) to quantify the dynamics of the western Adriatic coastal current and its role in along-shelf and cross-shelf sediment transport;

3) to make rigorous comparisons between observations and models of the transport processes on the Po delta and the coastal current in order to improve the predictions of sediment transport and morphodynamic evolution.

APPROACH

This research effort includes data analysis and model-data comparison. The data were collected during the field portion of the Po and Apennine Sediment Transport and Accumulation (PASTA) study, principally from the period from October, 2002 to June, 2003. The data include moorings and tripods deployed along the western margin of the Adriatic, from the mouth of the Po River to Pescara, including instruments deployed by Woods Hole Oceanographic Institution, University of Washington, Institut de Ciències del Mar (Barcelona) and the U.S. Geological Survey. The data analysis also involves hydrographic data collected during several cruises over the same interval. Additional timeseries and shipboard data from the Adriatic Circulation Experiment in the northern Adriatic Sea are also used for characterization of the far-field conditions.

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The data analysis addresses two main themes:

1) the processes affecting the suspended sediment distribution and dispersal in the vicinity of the Po delta, and

2) the dynamics and sediment transport associated with the western Adriatic coastal current.

Traykovski is principally engaged in the investigations of the Po delta. He is focusing in particular on the occurrence of fluid-mud flows that lead to significant cross-isobath transport. Geyer (in collaboration mainly with Kineke, Mullenbach and Sherwood) is examining the dynamics of the coastal current and its associated sediment transport processes.

The model-data comparison involves detailed comparisons of model results with moored and shipboard observations. The initial comparisons are used to refine the model parameterizations and input functions (e.g., bottom boundary conditions for sediment resuspension). Subsequent comparisons address model skill in resolving variability in physical processes (velocity, salinity variations) and sediment transport processes. The model also provides a framework for kinematic and dynamical analysis, for example to assess the relative roles of pressure gradients and wind stress in driving the along-shelf motions.

WORK COMPLETED

Traykovski's analysis of the processes on the Po delta is essentially complete, and the paper describing these processes has been published. It includes a comparison of the cross-shelf sediment transport, due mainly to gravity-driven flow in the wave boundary layer, relative to the along-shelf transport due to wind-forced motion. The paper also presents a model of the gravity-driven flow, applied to the Po delta and the Eel shelf. Geyer has completed his analysis of the coastal current dynamics, and he is working on a manuscript on that topic. Geyer and Traykovki are continuing to collaborate with Mullenbach, Sherwood and Kineke on the quantification of the sediment-transport processes along the Adriatic margin. Model-data comparisons are continuing, using ROMS. Geyer and Traykovski contributed to the completion and publication of the Harris et al. (2005) paper that describes the application of a wave-boundary-layer model within a coastal circulation model, with application to the Eel shelf.

RESULTS

Po Delta Processes

Traykovski et al. (2005) demonstrate that fluid-mud flows provide an important source of off-shelf sediment transport on the Po prodelta. The magnitude of sediment flux at the Tolle distributary, where the tripods were located, was actually greater in the along-shelf direction (driven by the Bora winds). However, model calculations indicate that at the Pila mouth, the larger sediment fluxes and steeper foreset beds may produce cross-shelf, gravity-driven transport that represents a more significant fraction of the total sediment flux from the Po, than could be accounted for by cross-shelf transport at the Tolle distributary.

Traykovski et al. (2005) also use the one-dimensional model of the gravity-driven flows to compare the processes on the Po delta to the Eel shelf. The model correctly predicts the magnitudes of sediment

fluxes in the two environments and the sharply contrasting depths of sediment transport in the two sites. Although the down slope gravitation forces at the two sites differ by an order of magnitude due to the higher concentrations and thicker flows at the Eel, the dynamic balance at both sites are essentially the same and are well described by a Chezy balance with a single drag coefficient for both sites. The much longer and larger waves on the Eel shelf result in gravity flows extending past 60-m water depth, whereas in the Adriatic, the gravity-driven transport extends only to 25-m (Figures 1 and 2).

Western Adriatic Coastal Current Dynamics and Sediment Transport

Geyer's analysis of the coastal current demonstrates that the wind field has fundamental importance in determining the structure of the coastal current. The freshwater transport at Chienti (Fig. 2) provides an integral representation of the strength of the coastal current. Large southward peaks in freshwater transport correspond to peaks in the Bora winds, which are best represented by the winds at Trieste, 300 km from the Chienti site where the freshwater flux is calculated. The transport of fresh water as well as sediment within the coastal current are fundamentally controlled by these extreme events; thus the focus of the analysis is in characterizing the dynamical coupling between the winds and the coastal current. In addition to addressing the horizontal transport processes associated with wind-mixing, Geyer is examining the Ekman transport and wind-induced mixing that occur during the Bora events and their consequences on the vertical structure of the coastal current and on cross-shelf transport.

Geyer and Traykovski are continuing to work with Mullenbach in the quantification of the along-margin sediment transport within the coastal current. There have been challenges with accurately quantifying the large peaks in suspended sediment that occurred during Boras, during which in situ measurements were impossible. Working with optical and acoustic backscatter data, we are coming up with improved estimates of these critical resuspension events in order to effectively quantify the flux.

Model-Data Comparison and Analysis

Data-model comparison and analysis is continuing. The emphasis over the last year has been to achieve a better understanding of the dynamical forcing variables. The model provides insight about the nature of the pressure distribution that cannot be discerned from the observations. For example, he model is being used to determine the means by which the wind forcing is communicated to the western Adriatic Coastal Current. This process is of critical importance to the model prediction of sediment transport. Sensitivity analysis is also being performed using the model to determine the influence of varying parameterizations of the bottom resuspension condition.

IMPACT/APPLICATIONS

The research is providing fundamental new insights about the dynamics and morphodynamics of river deltas and coastal current regimes. The identification of fluid-mud flows in a river delta region is of particular importance for mine countermeasures, navigation and acoustics. The coastal current dynamics and sediment transport processes have implications on larger spatial scales for the same naval issues.

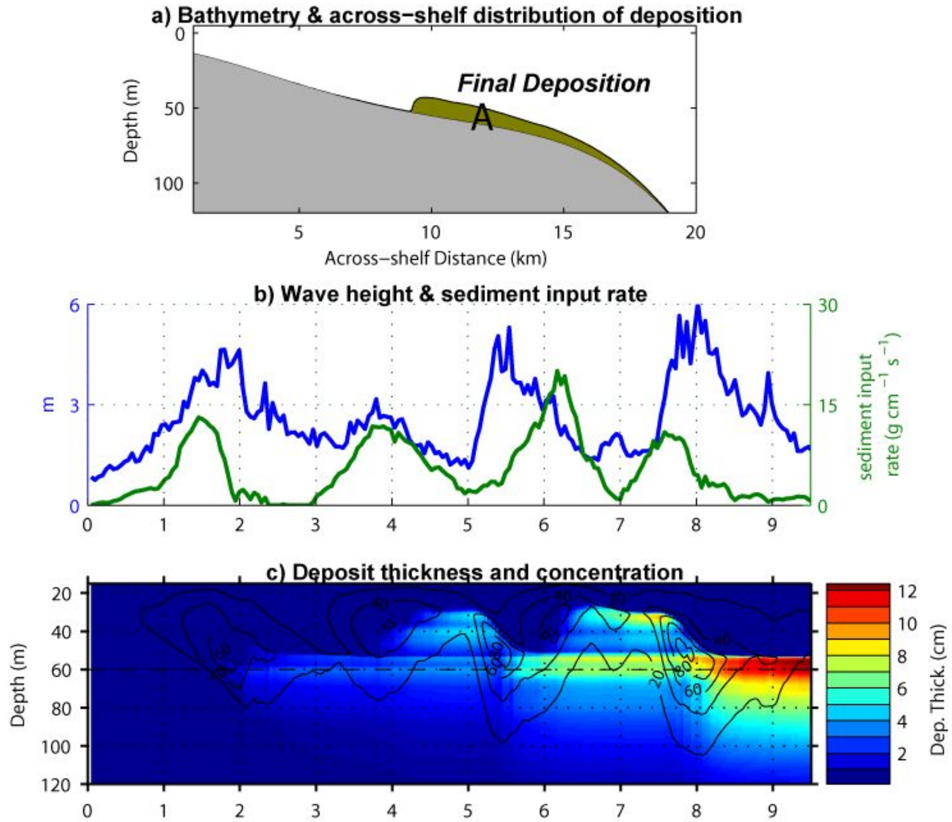

Figure 1. Model Runs for the Eel Shelf. a) Bathymetry, initial and final distribution of sediment deposition thickness. The vertical scale for the sediment deposition has been exaggerated by a factor of 100. The location of the tripod is indicated by A. b) Wave height (left y-axis) and sediment input rate (right y-axis, proportional to river discharge). c) Temporal and depth dependence of deposition (color scale) and suspended sediment concentration within the wave boundary layer (contours with units of g/l). A dashed line at 60 m depth depicts the tripod location. Due to the large waves and long wave period at the Eel site wave-supported turbidity currents were able to transport sediment to the 50 to 90 m isobath where it was deposited

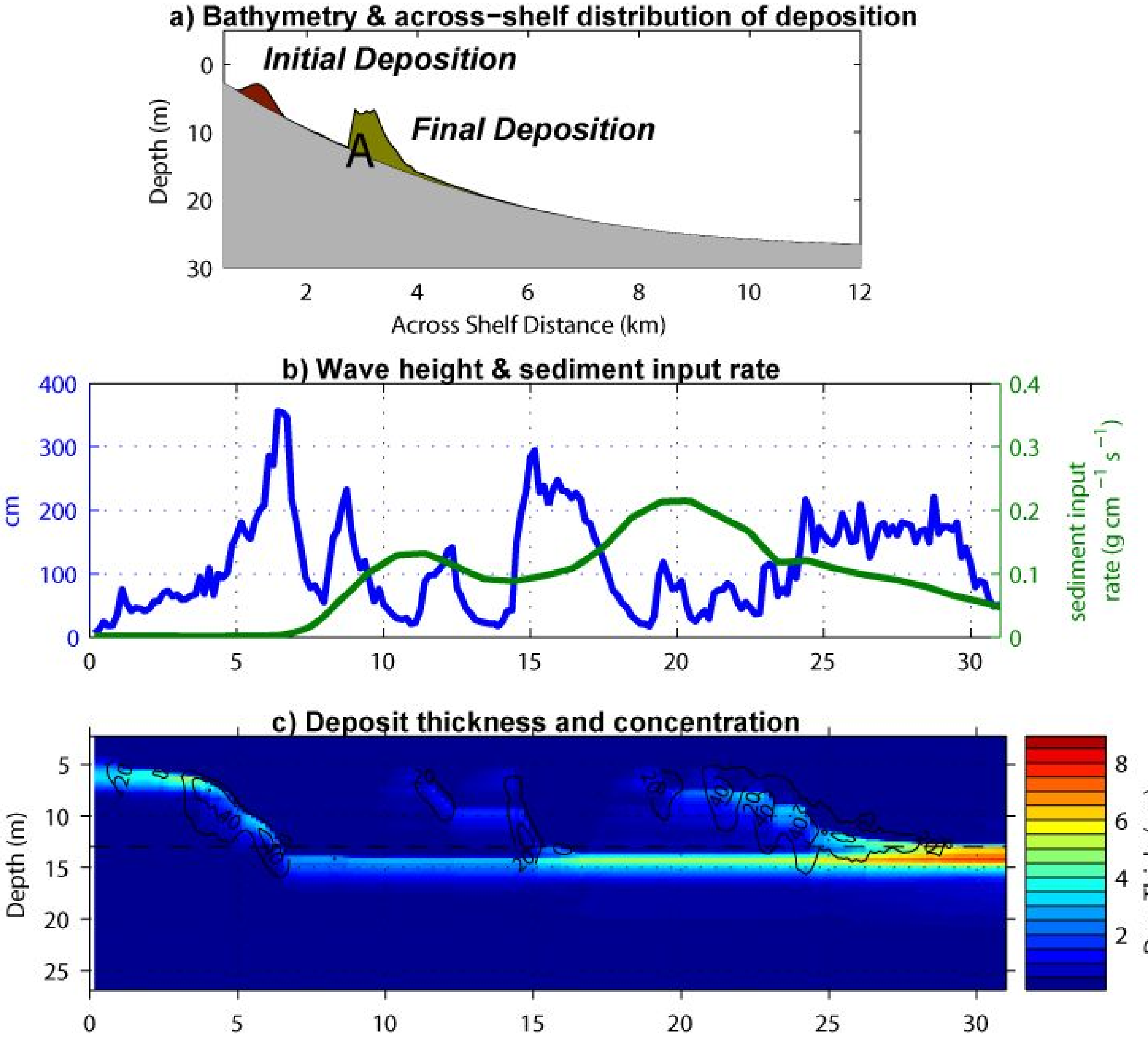

Figure 2. Model Runs for the Po prodelta. a) Bathymetry, initial and final distribution of sediment deposition thickness. The vertical scale for the sediment deposition has been exaggerated by a factor of 100. The location of the tripod is indicated by A. b) Wave height (left y-axis) and sediment input rate (right y-axis, proportional to river discharge). c) Temporal and depth dependence of deposition (color scale) and suspended sediment concentration within the wave boundary layer (contours with units of g/l). A dashed line at 13 m depth depicts the tripod location. Due to the slightly smaller waves compared to the Eel and significantly shorter wave period at the Po site wave-supported turbidity currents were able to transport sediment to the 13 to15 m isobath where it was deposited

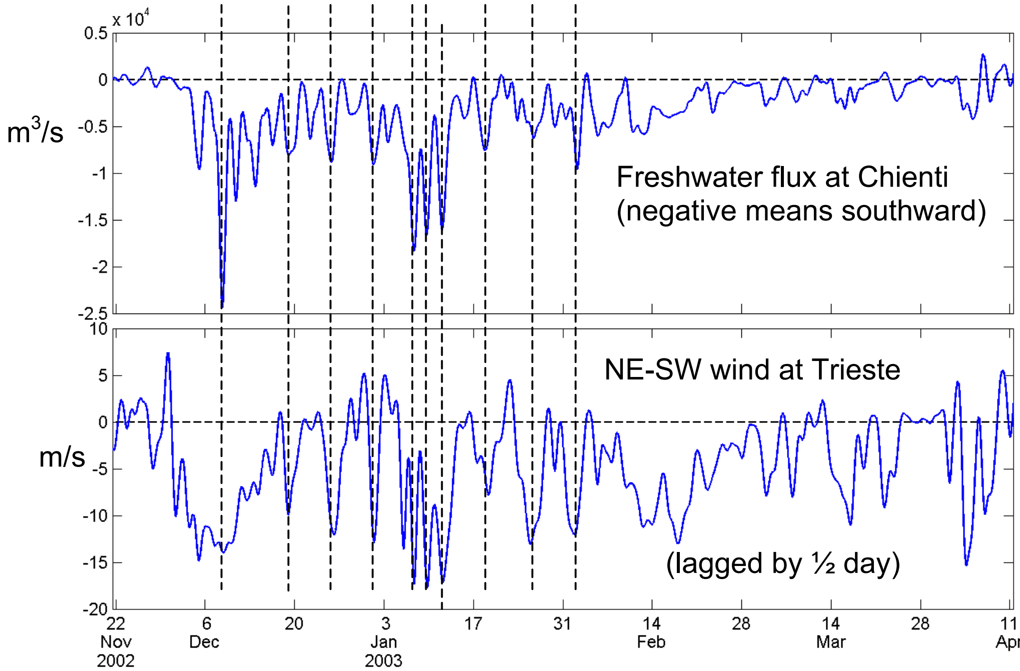

Figure 3. Freshwater flux at Chienti (top panel) and NE-SW winds at Trieste (lower panel). The freshwater flux matches the seasonally averaged freshwater inputs into the northern Adriatic, although there are major spikes in the freshwater flux that are due to the winds rather than freshwater flow events (examples indicated by vertical dashed lines). The strong Bora events (downward spikes in wind velocity) are critical agents for along-coast sediment transport.

PUBLICATIONS

Harris, C.K., P. Traykovski, W. R. Geyer. Flood Layer formation on the Northern California Shelf by near-bed gravitational sediment flows and oceanographic forcing. In press, *Journal of Geophysical Research, Oceans.*

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